Journal of Environmental Studies [JES] 2013. 10: 47-61
Original Paper

Physicochemical and microbiological studies of River Nile water in Sohag governorate

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Rec. 7 Apr, 2012 Accpt. 23 May, 2012

Abstract
Water quality assessment of River Nile has been studied in the Upper Egypt region between April 2011 and March 2012 to identify the relationship between the physicochemical parameters and microbiological characteristics. Thirty six water samples were collected during hot and cold seasons along the area extending from Tima to Dar-Elsalam cities, Sohag governorate, Egypt. Results indicated that the physicochemical parameters in all samples increased significantly in the hot season than cold season. In addition, the bacteriological assessment for water samples indicated that most of locations were polluted with faecal coliform and pathogenic bacteria which were identified as *Escherichia coli, Salmonella* spp., *Pseudomonas aeruginosa* and *Shigella* spp.
Key words: Physicochemical parameters, microbial diversity, correlations coefficient, River Nile water.

Introduction

Water is blessing of Allah and it is very precious resource of this planet where it is an established source of life. Water is considered as one of the nutrients, although it yields no calories. It has unique chemical properties due to its polarity and hydrogen bonds, consequently it is able to dissolve, absorb or suspend many different compounds. Water enters into the structural composition of cell, it is an essential component of diet and it is considered one of the essential components that support all forms of plant and animal life (Vanloon and Duffy, 2005). A correct balance in the sensory, chemical, physical and bacteriological qualities of water makes it drinkable thus; water in nature is not pure as it acquires contaminants from its surrounding, and those arising from humans and animals as well as other biological activities (Mendie, 2005).

Surface water quality management is the first step in ensuring an adequate supply of safe drinking water. Water quality deterioration may occur due to the sources of faecal pollution including grazing cattle, natural animals' populations, septic tanks, failed sewage systems and summer storm activity (Lehloesa and Muyima, 2000).

Main water resources in Sohag Governorate (Upper Egypt) are the surface water. Surface water includes the water in River Nile, the irrigation canals and the agriculture drains. Environmental pollution problems are the most serious national problems which requires great efforts at all levels; individual, group, national and international. Human and animal activities lead to pollution of River Nile because they serve as the concern to all agencies dealing with water resources management and planning so data collection, analysis, and interpretation are required to overcome heavy pollution. One major goal of surface water quality are data collection and estimation the changes in the concentration of various constituents (Yehia, and Sabae, 2011).

The water quality of Lake Nasser and the main stream of the River Nile from Aswan to Cairo are good but some traces of pollutants are present. Water quality in the irrigation and drainage canals deteriorates

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downstream and reaches alarming levels in the Delta (Abd El-Daiem, 2011). As the River Nile flows downstream from High Aswan Dam so the total salt load increase while the volume of water decreases because of additional drainage water and the continuous abstraction of water used for different purposes , this refer to River Nile is polluted northward in some locations, where it is used as disposal pathway for different types of wastes. The Nile in Egypt can be characterized to high, moderately and low polluted. Also, the canals have water quality similar to that at point of diversion from the Nile that receives a large amount of untreated effluents rich with organic and inorganic matter that cause Nile pollution. River Nile has an intensive self-purification capacity. The self-purification capacity of the River Nile is supposed to be high because of its ecosystem clearly reflect the impact of river flow control and precipitate all effluents of pollutants at the bottom. The water quality in the Nile downstream from Aswan to Cairo has changed dramatically as the Nile water became silt-free, less turbid, and with less velocity (El-Motassem *et al*., 1996 and El-Kady, 1997).

The River Nile water after High Dam construction led to the increasing in the concentration of phosphate and nitrate dissolved in the water body, and thereby stimulated algal and phytoplankton growth. Physical factors that influence the type and number of phytoplankton in River are flow rate, water level, light, temperature and solar radiation that plays an important role in the control of planktonic life (Shehata *et al*., 2008).

The dangers of pathogenic microbes in surface drinking water supplies were recognized. Microorganisms threat the safety of drinking water that is growing in industrialized nations that have long regarded themselves as immune to wide spread water-borne illness and carries so common in developing countries (Young, 1996). Microbial pathogens including (*E. coli, Shigella* spp., *Salmonella* spp., *Vibrio cholera*, Campylobacteria (toxins) and protozoa (*Giardia and Cryptosporidium* etc.) are major risks associated with water and waste water (Szewzyk *et al.,* 2000).

In the developing countries, drinking water is important route of transmission of diarrheal disease that is the leading cause of morbidity and mortality in children, risk increases in rainy season (Dangendorf *et al*., 2002). The associated risk with drinking water is the contamination resulting from human or animal faeces. Ice used for human consumption can also be contaminated with pathogenic microorganisms and become a vehicle for human infection through *E. coli*, and *Salmonella enteritidis* and many others (Faleao *et al*., 2002).

Presence of pathogens is usually accompanied by the presence of classic indicators of contamination such as Escherichia coli, Enterococci and other aerobic bacteria. Coliform bacteria have long been used to indicate faecal contamination of water and thus a health hazard. The Faecal streptococci are considered to be alternative indicators of faecal health hazards. Furthermore, classic indicators can be considered as efficient detectors of pathogens in most cases (Schaffter and Parriaux, 2002). Indicator organisms have several disadvantages making them less than ideal for indicating the possible presence of microbial pathogens. Traditionally, bacterial indicators of faecal contamination such as faecal coliforms and enterococci have been used to assess the microbial quality of water sources (Toze, 1999). The quality of drinking water is a complex issue, but it is a vital element of public health while poor water quality is responsible for the deaths of an estimated five million children annually (Holgate, 2000). The pathogenicity Enterobacteriaceae associated with certain components of cell walls which known as lipopolysaccharide (LPS) or endotoxin layer. Moreover, enteric pathogens are responsible for waterborne sickness (Karaboze *et al*., 2003).

The aim of this study was to assess the relationship between the physicochemical and microbiological characteristics of River Nile water in Sohag Governorate (central of Upper Egypt). Moreover, the study correlates the pathogenic microbes with the physicochemical parameters.

Materials and Methods:

Sampling:

Two sampling campaigns were conducted from May 2011 till March 2012 covering summer and winter two seasons in the area of study. Thirty-six water samples were collected from the River Nile from the middle, eastern and western bank by submerging to a depth of 40 cm along Sohag Governorate.

Physicochemical Analysis:

Different physical properties were measured by using standard technical methodologies. List of measured parameters includes, temperature, turbidity, pH, total dissolved salts (TDS), dissolved oxygen (DO) were recorded in tables. In addition, chemical analysis includes determinations of Na^{+}, K^{+}, NO_3^{-}, Cl^{-}, Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^{-}, NH_3, NO^{2-}, Cl_2.

Bacteriological Methods:

Number of total and pathogenic bacteria found in water was determined by serial dilution with sterile saline. For the determination of total bacterial count, serial diluted samples were grown on standard method agar while *Pseudomonas* isolation agar medium was used for isolation of *Pseudomonas aeruginosa* (Kiska and Gilligan, 1999). M- Endo agar LES (Difco) (McCarthy *et al*., 1961) was used for enumeration of total coliforms in water by membrane filter technique. Laurayl tryptose broth (Difco) (APHA, 1980) was used for verification of total coliforms. m-FC agar Base was used with rosolic acid in cultivating and enumerating faecal coliforms by the membrane filter technique (Geldreich *et al*.,1965). Azide dextrose broth medium was used for enumeration of fecal streptococci (Clesceri *et al.,* 1998). Kanamycin Aesculin azide agar (Ruoff *et al*., 1995) was used for verification of Fecal Streptococci. *E. coli* was counted by using MacConkey agar medium (MacConkey, 1905) after incubation at 44°C for 48 hrs X.L.D agar selective medium (Taylor, 1965) was for isolation of *Salmonella* spp. and *Shigella* spp.

Results:

Water were collected twice yearly for physicochemical and microbiological pollutants analysis, aiming to elucidate the temperature effect during hot and cold seasons. Tables (1-6) summarize the obtained physical, chemical and microbiological parameters in hot and cold sessions, respectively. Moreover, comparative analysis of the physicochemical and microbiological assessment was performed for the River Nile water through the area of Sohag governorate during the physical year, April 2011 to March 2012 to provide accurate statistical informative data for expected changes in the area under study as shown in table 7 and figures 1& 2.

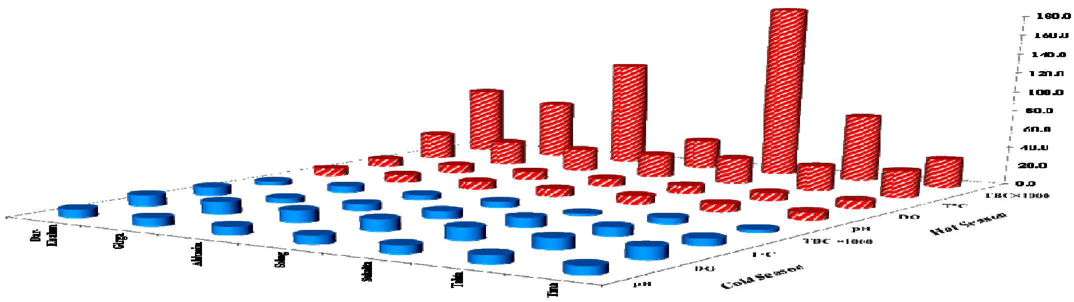

Figure 1: Schematic diagram of the relation between selected physicochemical parameters (temperature, pH, DO) and total bacterial count (TBC) in hot and cold seasons.

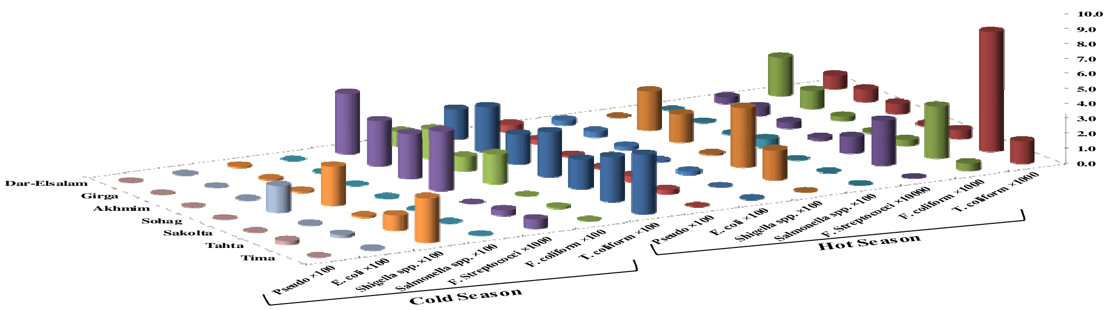

Figure 2: Correlations between the coliforms and pathogenic bacteria during hot and cold season in the River Nile at Sohag governorate

Physical properties:

the highest value of water temperature was 28°C, recorded at Akhmim, while the lowest record for temperature was 5°C at at Girga

pH value was alkaline at different sites during the hot season and it was ranged between 7.8 at Dar-Elsalam and 8.5 at Sakolta, however pH value was ranged between 8.37 at Tima and 8.53 at Dar-Elsalam, respectively during the cold season Electrical conductivity values were fluctuated within wide range between 286 and 371µs/cm at Tahta and Dar-Elsalam, respectively during hot season, while it was ranged between 277 µs/cm at Sohag and 298 µs/cm at Tima, respectively during the cold season. Total dissolved salts (TDS) content of water were fluctuated between 188.7 ppm at Tahta to 244.8 ppm at Dar-Elsalam during hot season, while TDS values were ranged between 138 ppm at Sohag and 149 ppm at Tima during cold season. Turbidity of Nile River water was ranged between 4.9 NTU at Girga and 6.5 at Tima during the hot season, while it was ranged between 4.9 NTU at Sohag and 6.5 at Girga during the cold season. Dissolved oxygen (DO) was fluctuated between 8.1 ppm at Sakolta to 8.5 ppm at Dar-Elsalam while, it was ranged from 11.5 ppm at Tahta to 12.8 ppm at Gerga region during cold season.

Chemical characteristics of Nile water:

The chemical characteristics values including Sodium, Potassium, Calcium, total hardness, Chloride ions, Sulphate ions, Nitrate ions, nitrite, ammonia, and Bicarbonate, were listed in table 1-6.

Site No.	Site	Physical properties					
		T(°C)	pH	EC (µhoms\cm)	TDS (ppm)	TU NTU	DO (ppm)
1	Tima	28±2	8.1	287	189	6.5	8.1
2	Tahta	26±2	8.2	286	188.7	5.9	8.2
3	Sakolta	27±2	8.5	287	189.4	6.3	8.1
4	Sohag	24±2	7.9	323	213.2	5.4	8.2
5	Akhmim	23±2	8.1	325	213.9	5.5	8.4
6	Girga	25±2	8.2	370	244.2	4.9	8.4
7	Dar-Elsalam	27±2	7.8	371.0	244.8	5.2	8.5
Average		25.7±2	8.1	321.3	211.9	5.67	8.23
Range		23-28±2	7.8-8.5	286-371	188.7-244.8	4.9-6.5	8.1-8.5

Table 1: Measured physical parameters for River Nile water at hot seasons.

No. Site	Site	Physical properties					
		T°C	pH	EC	TDS ppm	Tu NTU	DO ppm
1	Tima	7±2	8.37	298	149	7.1	12.2
2	Tahta	9±2	8.49	289	144	7.15	11.5
3	Sakolta	10±2	8.44	287	143	7.0	12.5
4	Sohag	8±2	8.39	277	138	6.2	11.9
5	Akmim	7±2	8.49	283	142	6.4	12.2
6	Girga	5±2	8.49	281	140.5	7.8	12.8
7	Dar-Elsalam	9±2	8.53	279	139	7.75	11.6
Average		7.86±2	8.46	284.9	142.2	7.1	12.1
Range		5-10±2	8.37-8.53	277-298	138-149	6.2-7.8	11.5-12.8

Table 2: Measured physical parameters for River Nile water at cold seasons.

No. Site	Site	Chemical properties												
		Cations						Anions						
		Na^+	K^+	Ca^{2+}	Mg^{2+}	T. H	Resid. Cl_2	Cl^-	SO_4^{2-}	NO_3^-	NO_2^-	NH_3	CO_3^{2-}	HCO_3^-
1	Tima	17	3	72	57	129	UDL	19.5	18	0.03	0.02	0.13	UDL	143.5
2	Tahta	15	2	74	54	128	UDL	18.5	19	0.03	0.02	0.13	UDL	142
3	Sakolta	21	3.4	75	53	128	UDL	22	17.5	0.03	0.02	0.13	UDL	144
4	Sohag	15	3	74.8	48	122.8	UDL	19	26.5	0.025	0.02	UDL	UDL	136.5
5	Akmim	18	4	74	49	123	UDL	19.2	26.1	0.025	0.02	0.15	UDL	137
6	Girga	22	6	84	46	130	UDL	24	25	UDL	UDL	0.19	UDL	148
7	Dar-Elsalam	20	8	85	45	131	UDL	23	25.2	UDL	UDL	0.16	UDL	148
Average		18.3	4.2	76.9	50.3	127.4	UDL	20.6	22.5	0.02	0.014	0.13	UDL	142.7

Table 3: Measured cations, anions concentrations (ppm) for River Nile water at hot seasons.

UDL : Undetectable limit T.H : Total hardness

No. Site	Site	Chemical properties												
		Cations						Anions						
		Na^+ ppm	K^+ ppm	Ca^{2+} ppm	Mg^{2+} ppm	T. H	Resid. Cl_2 ppm	Cl^- ppm	SO_4^{2-} ppm	NO_3^- ppm	NO_2^- ppm	NH_3 ppm	CO_3^{2-} ppm	HCO_3^- ppm
1	Tima	15	2.5	72	58	130	UDL	23	23	UDL	UDL	0.13	UDL	146
2	Tahta	19	4.5	73	56	131	UDL	23	22.5	UDL	UDL	0.13	UDL	146
3	Sakolta	13	3	71	57	128	UDL	22	22	UDL	UDL	0.12	UDL	145
4	Sohag	21	3.7	70	48	118	UDL	18.5	19	0.02	UDL	0.03	UDL	135
5	Akmim	14	2.8	71	50	121	UDL	19	19.5	UDL	UDL	UDL	UDL	133
6	Girga	23	7	84	46	130	UDL	20	25	UDL	UDL	0.04	UDL	142
7	Dar-Elsalam	16	5.9	86	46	132	UDL	20	26	UDL	UDL	0.04	UDL	156
Average		17.3	4.2	75.3	51.9	127.1	UDL	20.8	22.4	UDL	UDL	UDL	UDL	143.3

Table 4: Measured cations, anions concentrations for River Nile water at cold seasons.

Sample	Site	TBC	T. coliform	F. coliform	*F. streptococci*	*Salmonella* spp.	*Shigella* spp.	*E. coli*	*P. aeruginosa*
1	Tima	30×10^3	15×10^2	5×10^2	<1	<1	<1	<1	<1
2	Tahta	70×10^3	80×10^2	35×10^2	30×10^3	<1	200	<1	30
3	Sakolta	180×10^3	6×10^2	4×10^2	11×10^3	<1	400	20	40
4	Sohag	30×10^3	1×10^2	1×10^2	2×10^3	60	10	10	10
5	Akhmim	110×10^3	7×10^2	3×10^2	4×103	10	190	20	10
6	Girgra	60×10^3	8×10^2	12×10^2	6×103	<1	260	40	30
7	Dar-Elsalam	70×10^3	9×10^2	26×10^2	4×103	<1	<1	30	50
Average		785×10^3	18×10^2	12.3×10^2	8.14×103	10	151.5	17.14	24.3
Range		30×10^3 ~ 180×10^3	1×10^2 ~ 80×10^2	1×10^2 ~ 35×10^2	<1 ~ 30×10^3	<1 ~ 60	<1 ~ 400	<1 ~ 40	<1 ~ 50

Table 5: Microbiological characterization of (CFU) River Nile water at hot season for 100 ml sample.

CFU: Colony forming unit

Sample	Site	TBC	T. coliform	F. coliform	F. Streptococci	Salmonella spp.	Shigella spp.	E. coli	Pseudo
1	Tima	30×10^2	4×10^2	<1	6×10^2	<1	30	<1	<1
2	Tahta	60×10^2	3×10^2	1×10^2	4×10^2	<1	10	20	25
3	Sakolta	19×10^2	2×10^2	<1	<1.1	<1	<1	<1	<1
4	Sohag	60×10^2	3×10^2	2×10^2	4×10^3	<1	2.6×10^2	1.8×10^2	<1
5	Akmim	50×10^2	2×10^2	1×10^2	3×10^3	<1	<1	<1	<1
6	Girgra	65×10^2	3×10^2	2×10^2	6×10^3	<1	<1	<1	<1
7	Dar-Elsalam	43×10^2	2×10^2	1×10^2	4×10^3	<1	<1	<1	<1
Average		46.7×10^2	2.7×10^2	1×10^2	2.57×10^3	<1	37.7	28.6	3.57
Range		19×10^2 ~ 65×10^2	2×10^2 ~ 4×10^2	<1 ~ 2×10^2	<1.1 ~ 6×10^3	<1	<1 ~ 2.6×10^2	<1 ~ 1.8×10^2	<1 ~ 25

Table 6: Microbiological characters for River Nile water at cold season for 100 ml sample.

Bacteriological examination of River Nile water:

The results of bacteriological examination of collected samples from different sites along different regions of River Nile are shown in tables 5-6. The bacteriological examination including the total bacterial counts (TBC), total coliform (T. coliform), Faecal coliform (F. coliform), Faecal *streptococci* (*F. streptococci*), *Pseudomonas aeruginosa* (*P. aeruginosa*), *Salmonella* spp., *Shigella* spp. and *E. coli*.

TBC (cfu/ml) was fluctuated between 3×10^2 (cfu/ml) at Tima and 18×10^2 (cfu/ml) at Sakolta during hot season, while it was ranged between 19 (cfu/ml) at Sakolta to 65 (cfu/ml) at Girga during cold season. T. coliforms in hot season was ranged between 1×10^2 (cfu/100 ml) at Sohag site and 80×10^2 (cfu/100 ml) at Tahta, while it was ranged between 2×10^2 (cfu/100ml) at Dar-Elsalam to 4×10^2 (cfu/100 ml) at Tima during cold season.

coliforms in hot season was ranged from 1×10^2 (cfu/100 ml) in Sohag area to 35×10^2 (cfu/ml) at Tahta but it was undetectable at Tima and Sakolta whereas it was 2×10^2 (cfu/100 ml) at Girga and Sohag during cold season. *F. streptococci* was undetectable at Tima while it was ranged from 2×10^3 (MPN/100 ml) in Sohag to 30×10^3 (MPN/100 ml) at Tahta during hot season. Also, it was undetectable at Sakolta, while it was fluctuated from 4×10^3 (MPN/100 ml) to 6×103 (MPN/100 ml) at Tima.

Salmonella spp. count was 10 (cfu/ml) at Akhmim and 60 (cfu/ml) at Sohag but it was undetectable at other sites during hot season, while it was undetectable in all sites during cold season. *Shigella* spp. counts (cfu/ml) were undetectable at Tima, Dar-Elsalam but it was ranged from 10 (cfu/ml) in Sohag to 4×10^2 (cfu/ml) at Sakolta during hot season, meanwhile it was detectable as (10, 30 and 2.6×10^2) at Tima, Thata and Sohag, respectively. But it was undetectable at other sites during cold season. *E. coli* was ranged from 10 (cfu/ml) at Sohag to 40 (cfu/ml) Girga, but it was undetectable at Tima, Tahta during hot season, while it was detected only in Tahta and Sohag (20, 1.8×10^2), respectively during cold season. *P. aeruginose* was undetectable at Tima but it was fluctuated between 10 (cfu/ml) in Sohag and Akhmim to 50 (cfu/ml) at Dar-Elsalam during hot season, while it was detectable only in Tahta (25 cfu/ml) during cold season.

Discussion:

The quality of drinking water has been decreased during this century due to discharging of wastewater into water resources as well as environmental pollutants. The major global health problems, cross adaption of microbial population to structurally related chemicals, may play an important role in the practical development and application of bioremediation techniques (Liu and Jones, 1995). The present study was planned to monitor the quality of water consumed by the urban and rural population of Sohag governorate for drinking water purposes and the impact of the water qualityon their health. The population constitutes mostly of the low- income class which cannot afford bottled water from markets. Also, treated water is not present in all hospitals where patients have already suppressed or compromised immune systems. All the schools and universities do not have treated water. The authorities are very much concerned both about the quality and the quantity of water as they are supplying with reference laboratories belonging to the ministry of health and population. Due to shortage of treated water government has installed a large number of tube wells. However it is a fact that there is no guidance from government side for these installation (i.e.. depth of digging, strata penetration, lining and other material) so during our studies we could detect *Shigella* spp, Faecal coliform, total coliform, *E. coli* and *Faecal streptococci* that are indicators for water contamination. Abo-Amer *et al*. (2008) reported that some groundwater stations were polluted with coliform group and pathogenic strains.

Significant correlations between the physicochemical parameters and microbial characteristics of River Nile water are summarized in table (7) as well as in figures 1 and 2. Decrease or increase the Nile water Temperature depends mainly on the climatic conditions, sampling times, and the number of sunshine hours as well as it is also affected by characteristics of water environment such as turbidity, wind force, plant cover and humidity (Mahmoud, 2002).

Air and water temperature showed positive correlation during hot and cold season. Recorded temperature at different spots at Sohag governorate showed a positive correlation with the measured microbial pathogenic species (total bacterial count, total coliform, Faecal coliform, *Faecal streptococci*, *Salmonella* spp., *Shigella* spp. and *pseudomonas aeruginosa*). The correlation coefficients (r) between these microbial species and the temperature (see table 7), were found to be 0.72, 0.71, 0.36, 0.56, 0.25, 0.4 and 0.64, respectively. This indicates strong effect of water temperature on bacterial growth. These results are in accordance with previous reported findings (Sabae *et al*., 2006).

Control variables	**T^0C**	**pH**	**TDS**	**DO**	**SO_4^{2-}**	**NO_3^-**	**NH_3**	**HCO_3^-**	**TBC**	**T. coliform**	**F. coliform**	***F. streptococci***	***Salmonella* spp.**	***Shigella* spp.**	***E. coli***	***Pseudo***
$T\ ^0C$	1.000															
PH	-0.718	1.000														
TDS	0.874	-0.825	1.000													
DO	-0.983	0.711	-0.870	1.000												
SO_4^{-2}	-0.081	-0.326	0.288	0.031	1.000											
NO_3^-	0.633	-0.322	0.293	-0.671	-0.441	1.000										
NH_3	0.516	-0.268	0.540	-0.459	-0.013	0.025	1.000									
HCO_3^-	0.036	0.118	0.056	0.010	0.292	-0.413	0.436	1.000								
TBC	0.722	-0.236	0.594	-0.727	-0.179	0.566	0.470	-0.023	1.000							
T. coliform	0.716	-0.487	0.565	-0.663	-0.299	0.422	0.642	0.150	0.400	1.000						
F. coliform	0.364	-0.034	0.179	-0.373	-0.310	0.433	0.154	-0.031	0.420	0.198	1.000					
F. streptococci	0.567	-0.494	0.535	-0.526	-0.103	0.205	0.430	0.147	0.328	0.493	0.760	1.000				
Salmonellaspp.	0.252	-0.502	0.304	-0.326	.408	0.327	-0.412	-0.352	-0.001	-0.291	-0.134	-0.168	1.000			
Shigella spp.	0.400	0.092	0.294	-0.431	-0.371	0.514	0.314	-0.154	0.734	0.184	0.479	0.201	-0.152	1.000		
E. coli	-0.122	0.011	-0.066	0.094	-0.209	0.151	-0.144	-0.319	-0.047	-0.088	-0.065	-0.051	-0.081	0.459	1.000	
pseudo	0.643	-0.394	0.674	-0.621	-0.012	0.117	0.581	0.258	0.672	0.349	0.425	0.671	-0.075	0.422	-0.015	1.000

Table 7: The correlation coefficients between pathogenic bacteria and other water quality ingredients in studied River Nile water.

On the other hand, correlation analysis showed that water temperature recorded a high negative correlation with DO and pH (r= -0.98 and -0.72), respectively while positive correlation was calculated with NO_3^- , NH_3, HCO_3^- and TDS (r=0.63, 0.52, 0.04 and 0.87), respectively. It is observable that DO concentration is inversely proportionated with water temperature. Similar results were obtained by Sharma *et al*. (2008) who found that temperature has negative correlation with DO (~ r= -0.9) and positive correlation with nitrate in Narmado River, India.

pH value has an effect on the biological, chemical reactions, as well as it controls the metal ion solubility and thus it affects the natural aquatic life. More specifically, it was reported that desirable pH for fresh- water is in the ranges of 6.5-9 and is 6.5-8.5 for aquatic life. Moreover pH could control the pathogenic microorganism growth (Zamaxaka *et al*., 2004). The pH range for Nile water at Sohag governorate showed that pH ranged towards the alkaline side during cold season. The obtained results indicated that pH values of Nile water were slightly fluctuated at most stations during hot and cold season. Our results were in accordant with Toufeek and Korium (2009).

Conductivity measurements indicate the presence of dissolved salts and electrolytic contaminants, but it gives no information about specific ion compositions. Previous studies concluded that water taste is objectionable at highest conductivity, while taste is satisfactory at low conductivity (Adekunle *et al*., 2007).

EC for Nile water was variable and it was somewhat high from Dar-Elsalam to Sohag due to the solutions of most inorganic compounds and more abundant ions resulted from agricultural drainage which has high conductivity (APHA, 1995). EC should be less than 700 µs/cm as adopted from Ayers and Westcott (1985). Our results are in accordance with Sabae *et al*. (2006).

TDS may be organic or inorganic in nature and many are undesirable in water and produce displeasing color, tastes and odors and may also exert osmotic pressure that affect aquatic life or become carcinogenic especially halogenated compounds. TDS concentrations for Nile water samples were almost within the permissible limits during hot and cold season. High concentrations of TDS decrease the palatability of water and may also cause gastro-intestinal irritation in humans and laxative effects particularly upon transits (WHO, 1997) TDS should be less than 450 mg/l. There was a strong positive correlation between TDS and EC in addition to turbidity values which revealed positively strong correlation to each other (r= +0.99), so our results were in accordance with Toufeek and Korium (2009).

Water turbidity is caused by suspended matter such as clay, silt, and divided organic and inorganic matters, planktons and water microscopic organism. The purity of the natural body of water is a major determinant of the condition and productivity of the sustain (APHA, 1998). The turbidity degree of the stream water is an approximate measure of the intensity of the pollution (Siliem, 1995). High turbidity indicates the presence of organic suspended material, which promotes the growth of microorganism (Momba *et al*., 2006). River Nile water turbidity values were slightly high during cold season. Abdo *et al*. (1998) had reported that the transparency lower values were recorded during hot season may be due to the flourishing of phytoplankton while the values were recorded during cold season were somewhat high due to the decrease in water level during drought period.

The Water DO is an indicator of water quality. DO concentration of unpolluted water is normally about 8-10 ppm at $25\pm2^{\circ}C$. DO is very important factor for the aquatic organisms, because they affect their biological process. For the oxidation of the organic matters and the sediments, the complex organic substances are converted to simple dissolved inorganic salts which could be utilized by the micro and macrophyte (Okbah and Tayel, 1999). DO concentration was found to be higher in the cold season comparing with the hot season (Anon, 2007). WHO suggested that the standard of DO is not less than 5 mgO_2/l. DO values during hot and cold season showed negative correlation with NO_3^-, NH_3, total bacterial count, total coliform, Faecal coliform, *Faecal streptococci*, *Salmonella* spp., *Shigella* spp. and *pseudomonas aeruginosa*. Quantitatively the DO correlations coefficients with other physicochemical and microbiological parameters were (r= -0.67, -0.45, -0.72, -0.66, -0.37, -0.32-0.43 and -0.62, respectively). DO had strong effect on the bacterial growth especially during the cold season, also DO has shown strong negative correlation with water temperature of Nile water (r= -0.97), (Abdel-Satar, 2005).

The average values of major cations that include Na^+, K^+, Ca^{2+} and Mg^{2+} during hot and cold seasons showed that Na^+ and K^+ ion concentrations were at permissible limit guidelines according to (WHO, 2006). The lower concentration of K^+ compared with Na^+ in Nile water might be due to the high mobility of Na^+ ions and dominates in the natural solutions (Ramanathan *et al*., 1994).

Temporary hardness is resulted from bicarbonates and carbonates of Ca^{2+} and Mg^{2+}, while permanent hardness (or non-carbonate hardness) is resulted from nitrates, sulphates and chlorides of Ca^{2+} and Mg^{2+}. The former can be removed by simple boiling, however boiling cannot remove the latter Water with total dissolved salts (TDS) values exceeding 120 mg/L are considered hard, more than 180 mg/l are very hard (McGowan, 2000) and waters with TDS values less than 60 mg/L are considered soft hardness. Calculated Ca2+ and Mg2+ ions concentrations during hot and cold season showed low variation and were at permissible limit guidelines as 75 ppm, and 50 mg/l respectively, according to (WHO, 2006). These results agree with previous finding obtained by Ramkumar *et al*. (2010). The average concentration of Cl ions in the Nile River water was 20.0±3.0 ppm. This value is in accordance with WHO (2006).

The recorded SO_4^{2-} concentrations are slightly fluctuated at most station during hot and cold season. Statistical analysis showed that the SO_4^{2-} concentration correlates with DO, TDS, HCO_3^- and *Salmonella* spp. by r= 0.03, 0.28, 0.29 and 0.41, respectively while it has negative correlation with TBC, total coliform, *sS*, *pseudomonas aeruginosa* and *E. coli*. by r = -0.18, -0.30, -0.37, -0.21 and -0.012, respectively. The increasing in its concentration at all stations in Nile water is due to death and decomposition of aquatic microorganisms then oxidation of liberated sulpher into sulphate in presence of high DO concentration especially during drought period at cold season. All results were at the permissible limit guidelines according to WHO (2006) and in accordance with Abdo (1998) and El-Haded (2005).

Nitrate ions represent the highest oxidized form of nitrogen. The presence of nitrate ions indicates that water was polluted with old faecal pollution but does not represent an immediate threat (Papa, 2001). High nitrate concentration in water is dangerous to pregnant women and possesses a serious threat to infants younger than three to six months old, because of its ability to cause methaemoglobinaemia or blue-baby syndrome, in which blood loses its ability to carry sufficient oxygen (Burkart and Kolpin, 1993). All results were at the permissible limit guidelines (less than 45 mg/l) according to WHO (2006). Nitrate ions in Nile water were increased at all stations during hot season and it had positive correlation with water temperature, TDS, NH_3, TBC and total coliform, Faecal coliform, *Faecal streptococci*, *Salmonella* spp, *Shigella* spp, *E. coli* and *pseudomonas aeruginosa* where r = 0.63, 0.30, 0.03, 0.57, 0.42, 0.43, 0.21, 0.33, 0.52, 0.15 and 0.12, respectively. But it had negative correlation with pH, DO, SO4-2, HCO3- where r = -0.32, -0.67, -0.44 and -0.41, respectively. High nitrate levels are often accompanied by bacterial contamination. Our results were in accordance with Abdo (1998) and Sabae *et al*. (2006).

The increase in NO_2^- during hot season due to the decomposition of organic matter and presence of *nitrozomonas* bacteria that oxidize ammonia to nitrite (NO_2^-). Our results were in accordance with Rabeh (2001).

The presence of ammonia in drinking water is considered as an indicator of recent faecal pollution from sewage. Ammonia may result from fertilizers that are present in soil and it is relatively easily oxidized to nitrite and finally to nitrate (Karavoltsos *et al*., 2008) and it possesses a serious threat to public health. The average values of ammonia concentrations during hot and cold season revealed that the average value was 0.15 ppm. The high temperature accelerates the reduction rate of nitrate into ammonia also, ammonia in Nile water had positive correlation with temperature, NO_3^-, TBC, total coliform, Faecal coliform, *Faecal streptococci*, *Shigella* spp and *Pseudomonas aeruginosa* by r= 0.52, 0.03, 0.47, 0.64, 0.16, 0.43, 0.31 and 0.58, respectively and it had a negative correlation with other parameters. According to WHO (2006) NH_4^+ results were at permissible limit guidelines (Not exceed 0.5 mg/l).

carbonate (CO_3^{2-}) ions concentration were undetectable in Nile water due to the composition of water as (Na-HCO_3) or may be due to the flourishing of phytoplankton during hot season that consuming carbonate ions (Abdo, 1998). The increase in the bicarbonate concentration in hot season may be due to the increase in water temperature that accelerates the decomposition of organic matter by bacteria. HCO_3^- is the final product of this base (Abdo, 2002). The HCO_3^- values showed positive correlation with total coliform, *Faecal streptococci* and *Pseudomonas aeruginosa* r= 0.15, 0.15 and 0.20, respectively. The amount of HCO_3^- in water plays an important role in bacteriological assessment for water quality.

Heterotrophic plate count bacteria (HPC) are commonly used to assess the general microbiological quality of water. Drinking water quality specifications world-wide recommend HPC limits from 100 to 500 (cfu/ml), (WHO, 2001). The distribution and seasonal variations of the total bacterial counts during hot season total bacterial count was ranged from 3×10^4 to 18×10^4 (cfu/100 ml), while at cold season total bacterial count was ranged from 19×10^2 (cfu/100 ml) to 65×10^2 (cfu/100 ml).The maximum bacterial counts were detected during the hot season, reflecting the effect of high content of organic matter due to flourishing of phytoplankton which increased active multiplication of the bacteria. Our results were in accordant with Sabae *et al*. (2008). It is obvious from table (7) TBC in Nile water had strong positive correlation with temperature, TDS, NO_3^-, NH_3, *Shigella* spp and *Pseudomonas aeruginosa* by r= 0.72, 0.60, 0.57, 0.47, 0.73 and 0.67, respectively. Our results were in agreement with the results of Sabae and Rabeh (2006).

The coliform bacteria in water are considered as indicators of bacterial pollution of human or animal feces. Drinking water is not a natural environment for coliform bacteria, their presence in water indicates microbial pollution (Rompré *et al*., 2002). Total coliforms were ranged from 1×10^2 to 80×10^2 (cfu/ 100ml) during hot season and cold season the total coliforms were ranged from 2×10^2 to 4×10^2 (cfu/100 ml). The high counts of total coliform might be due to pollution by industrial activities discharging their wastes to the Nile water between Aswan and Cairo (Saleh, 2009). All results of Nile water were higher than the permissible limit guidelines (TC should not exceed 5000 cfu/100 ml) according to Tebbutt (1998). Our results agree with Sabae and Rabeh (2006).

Fecal coliform is a portion of the coliform bacteria group originating in the intestinal tract of warm-blooded animals that pass into the environment as feces. Fecal coliform often is used as an indicator of the bacteriological safety of a domestic water supply. Faecal coliform count for Nile water was ranged from 1×10^2 to 35×10^2 (cfu/100 ml) during hot and cold seasons, the discharge of human and animal wastes in Nile water. Total and Faecal coliforms had strong positive correlation with temperature of r= 0.72 and 0.36, respectively. Our results were in accordance with Abo-Amer *et al*. (2008) who reported that untreated water samples were slightly contaminated by faecal coliforms. Shash *et al*. (2010) found that total and fecal coliforms were detected in Nile water.

Faecal streptococci are associated with fecal material from human and other warm-blooded animals and their presence in water indicates the potential incidence of enteric pathogens that could cause illness in exposed individuals (Dufour, 1984). Any bacterial cell of fecal indicator were found in drinking water, considered to be contaminated with feces, therefore unsuitable for drinking purposes according to WHO guide line for drinking water (WHO, 2003).

Faecal streptococci count ranged from <1.1 to 30×10^3 (cfu/100 ml) during hot season, while at cold season they were ranged from <1.1 (cfu/ml) to 6×10^3 (cfu/ 100 ml). high amount of *Faecal streptococci* was found at Tahta area during hot season due to the high temperature also the discharge of human and animal wastes in the river Nile. The presence of fecal streptococci and absence of fecal coliform in same water samples, mainly attributed to bacterial tolerant to environmental condition (WHO, 2006) described streptococci organism as rarely multiply in water, but they live longer in water than the coliform, and more resistant to heat, Alkali and salts (Shekha, 2008). Our results are agreed with Sabae and Rabeh (2007). TBC, TC, FC and FS respectively, showed that the high counts of bacterial indicators were detected in the hot season which might be attributed to high temperature and the discharge of waste water in the River Nile water during this season.

Salmonella is considered as one of the primary bacterial foodborne pathogens to humans and it is commonly presented in raw water (Little *et al*., 2007). Low level of contamination of water rarely leads to disease developing because between 10^5 and 10^7 organisms have to be ingested before development. *Salmonella pratyphi* was recorded in surface waters all over the British Isles (Gray, 1994, 2008). *Salmonella* spp were detected only during hot season at Sohag station and they was ranged from 10 to 60 (cfu/100 ml) indicating that Nile water may be contaminated with feces or wastes belonging to human and animal activities. *Salmonella* was found only in those samples which were positive for coliforms. *Salmonella* spp had positive correlation with temperature, SO_4^{2-} and NO_3^- (r= 0.25, 0.30 and 0.41), respectively. Similar findings were reported by Bhatta *et al*. (2007).

Shigella spp. is usually acquired by drinking water contaminated with feces or by eating food washed with contaminated water. Elimination of the contamination caused by fecal matter is the most important parameter of water quality. Human faecal matter is generally considered a greater risk to human health as it contains human enteric pathogens that are causal agents of diarrhea (Scott *et al*., 2008). Although *Shigella* causes food-borne diseases, shigellosis outbreaks resulted from consumption of contaminated water especially in developing countries with inadequate sanitation facilities. Total count for *shigella* spp was ranged from <1 to 4×10^2 (cfu/100 ml) during hot season while at cold season the total count for *shigella* spp was ranged from <1 to 2.6×10^2 (cfu/100 ml). The high amount of *shigella* was detected at Sohag station due to discharging of wastes and animal feces in this area. The presence of *Shigella* spp. (60%) of all the samples during hot season and 30% in cold season might be due to unsanitary environmental condition and secondary faecal contamination from an intermediary sources and this is in accordance with Ihejirika *et al*. (2011). *Shigella* spp had positive correlation with temperature, NO_3^-, NH_3, TBC, TC, *E. coli* and *Pseudomonas aerugoinosa* (r= 0.40, 0.51, 0.73, 0.18, 0.46 and 0.42). Our results were in agreement with the report of Emch *et al*. (2011). Also, it was supported by the previous reported works of Ihejirika *et al*. (2011).

Thermotolerant coliforms were represented by *E. coli* as indicator of fecal contamination of drinking water (WHO, 2001). The presence of *E. coli* in water is a common indicator of faecal contaminations of water bodies. Some *E. coli* strains live as harmless commensals in animal intestines. *E. coli* is a widely used indicator of fecal contamination in External contact and subsequent ingestion of bacteria from fecal contamination can cause detrimental health effects (Money *et al*., 2009). Total count for *E. coli* was ranged from <1 to 40 (cfu/100 ml) during hot season while at cold season the total count for *E. coli* was ranged from <1 to 1.8×10^2 (cfu/100 ml). Presence of *E. coli* (66.6%) of all the samples during hot season and 22.6% in cold season might be due to unsanitary condition of the environment and discharging of animal feces in Nile water during hot season. Our results were in accordant with Ihejirika *et al*. (2011).

Pseudomonas aeruginosa is a common bacterium has very simple nutritional requirements which can cause disease in animals and humans (Todar, 2004). *P. aeruginosa* can be found in feces, soil, water, sewage and it can multiply in water environments also, it can be waterborne-disease, (Bartram *et al*., 2003). *Pseudomonas aeruginosa* can cause a range of infections but rarely lead to serious illness in healthy individuals without some predisposing factor. It can damage sites such as burn and surgical wounds, thus it is an opportunistic pathogen in humans and a major cause of nosocomial infection (Römling *et al*., 1994). Total count for *P. aeruginosa* was ranged from <1 to 50 (cfu/100 ml) during hot season while at cold season the total count for *P. aeruginosa* was detected in Tahta station as 25 (cfu/100 ml). The presence of *P. aeruginosa* (66.6%) of all the samples during hot season and 7.69 % in cold season might be due to unsanitary condition and fecal contamination resulted from human and animal activities. Our results were in agreement with Purohit *et al*. (2003).

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دراسات فيزوكيمائية وميكروبية على مياه نـهر النيل بمحافظة سوهاج

تمت دراسة تقييم مياه نهر النيل في صعيد مصر بمحافظة سوهاج خلال الفترة ما بين شهري ابريل ٢٠١١ ومارس ٢٠١٢ وذلك من اجل معرفة العلاقة ما بين العوامل الفيزوكيمايائية والميكروبيولوجية. حيث تم تجميع العينات في الموسمين الحار والبارد وذلك في المنطقة التي تمتد من مدينة طما ومدينة دار السلام بمحافظة سوهاج وقد أوضحت النتائج التي سجلت في الجداول المختلفة ان العوامل الفيزوكيميائية تزداد في الموسم الحار مع زيادة درجة الحرارة فيما عدا نسبة الأكسجين الذائب والتي تتناسب عكسيا مع درجة الحرارة. أوضحت أيضا الدراسة الميكروبية والعد الميكروبي لتلك العينات أن معظم هذه العينات كانت ملوثة بالأنواع المختلفة من البكتريا القولونية والبرازية والأنواع الممرضة وخاصة الاشيريشيا كولاى والسالمونيلا والشايجيلا والسيدوموناس ايريجنوسا والى تسبب العديد من الأمراض.